AD-A097 742 PERSON-SYSTEM INTEGRATION INC ALEXANDRIA VA F/G 5/9
SIMULATOR SICKNESS OCCURRENCES IN THE 2E6 AIR COMBAT MANEUVERIN--ETC(U)
FEB 81 J MCGUINNESS, J H BOUWMAN, J M FORBES N61339-80-M-3196
UNCLASSIFIED PSI-80-4 NAVTRAEQUIPC-80-C-0135-450 NL

1 OF 1
AD A
097742

END
DATE
FILMED
5-81
DTIC

LEVEL II

(12)

AD A098 742

(18) (19)

Technical Report NAVTRAEQUIPCEN 80-C-0135-4500-1

(6) SIMULATOR SICKNESS OCCURRENCES IN THE 2E6 AIR COMBAT MANEUVERING SIMULATOR (ACMS).

(10) James McGuinness, J. H. Bouwman and Jim M. Forbes
Person-System Integration, Limited
3012 Duke Street
Alexandria, Virginia 22314

(11) Feb[redacted]81 (12) 46

DTIC
ELECTE
APR 1 5 1981
S A

(9) FINAL REPORT (3) JULY-4 NOV[redacted]80,

(14) PSI-80-4

(15) N61339-80-M-3196

NAVAL TRAINING EQUIPMENT CENTER
ORLANDO FLORIDA 32813

394457

81 4 13 134

NAVTRAEQUIPCEN 80-C-0135-4500-1

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
NAVTRAEQUIPCEN 80-C-0135-4500-1

2. GOVT ACCESSION NO.
AD-A097742

3. RECIPIENT'S CATALOG NUMBER

4. TITLE *(and Subtitle)*
Simulator Sickness Occurrences in the 2E6 Air Combat Maneuvering Simulator (ACMS)

5. TYPE OF REPORT & PERIOD COVERED
Final Report
3 July - 4 November 1980

6. PERFORMING ORG. REPORT NUMBER
PSI 80-4

7. AUTHOR(s)
James McGuinness, J. H. Bouwman and Jim M. Forbes

8. CONTRACT OR GRANT NUMBER(s)
N61[illegible]-[illegible]-[illegible]-[illegible]16

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Person-System Integration, ~~Limited~~
3012 Duke Street
Alexandria, Virginia 22314

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
NAVTRAEQUIPCEN
Task 0275

11. CONTROLLING OFFICE NAME AND ADDRESS

12. REPORT DATE
February 1981

13. NUMBER OF PAGES
49

14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*

15. SECURITY CLASS. *(of this report)*
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Simulator sickness, motion sickness, disorientation, Air Combat Maneuvering Simulator (ACMS), nausea, simulation/simulators visual/motion cueing.

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

In March 1980, it was reported that a few Navy personnel were experiencing some disorientation or discomfort while flying the Air Combat Maneuvering Simulator (ACMS), designated Device 2E6. Recognizing the need for pursuing this matter further, a study was initiated to determine the extent of the problem.

This report describes the methods and results of a preliminary study undertaken to assess the rate of occurrence and the (cont)

DD FORM 1473, 1 JAN 73 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601

UNCLASSIFIED 394

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

degree of severity of "simulator sickness" experienced by individuals who have "flown" the Device 2E6, Air Combat Maneuvering Simulator.

Twenty-seven percent of the aircrews from F-4 and F-14 squadrons at NAS, Oceana, Virginia Beach, Virginia experienced varying symptoms during and/or after use of this simulator. Sixty-one percent of those experiencing symptoms reported persistence of the symptoms from fifteen minutes to six hours after a simulator session ended. At the time of the study, this was a new simulator, installed in November 1979, therefore, the period of observation was limited.

Further investigation of simulator sickness is planned when a structured curriculum is incorporated into the training program and modifications are made to the simulator.

SUMMARY

A few fighter crews using the Navy's 2E6 Air Combat Maneuvering Simulator (ACMS) have experienced physiological effects similar to motion sickness symptoms.

A questionnaire was designed to collect data to define the incidence and severity of this "simulator sickness." The questionnaire was given to 66 aircrew members on an individual basis. The sample included participants from both F-4 and F-14 squadrons at NAS Oceana.

Twenty-seven percent (18) of the aircrews experienced varying degrees of "simulator sickness" during, and/or after use of the 2E6 Air Combat Maneuvering Simulator (ACMS). Sixty-one percent (11) of those experiencing symptoms reported persistence of the symptoms from 15 minutes up to 6 hours after a simulator session ended. The data compiled in this study indicates that susceptibility increases with experience levels. The highest incidence rate occurred among those aircrew members (22) with more than 1500 flight hours (47 percent) as compared to 18 percent for 44 crew members with 1500 or fewer flight hours.

A recent USAF study revealed that 88 percent of aircrews who used the simulator for air-to-air combat (SAAC) also reported simulator sickness symptoms. The SAAC differs from the 2E6 in the type of display used and the manner of use.

At the time of the study, the Device 2E6 was a new simulator, installed at NAS Oceana in November 1979 and commissioned in February 1980.

Significant changes in the length or intensity of training in the 2E6 ACMS may be accompanied by corresponding changes in the occurrence of simulator sickness. Further examination of simulator sickness rates should be pursued when a training curriculum is defined and modifications to the simulator (such as the addition of ground growth cues) are made.

A

PREFACE

The authors wish to acknowledge the assistance and cooperation of the Navy personnel who contributed to this study. In particular, appreciation is expressed to the Commander, Fighter Wing One and officers of the Oceana based Fighter Squadrons.

We also wish to acknowledge the willingness of the Tactical Research Branch, Air Force Human Resources Laboratory and the Operating Location of the 57th Tactical Fighter Wing in providing the briefings and discussions which were so valuable in comparing Air Force and Navy experiences with simulator sickness. In particular, we would like to express our appreciation to Lieutenant Colonel Joe E. Robinson, 57TTW/OLAA/CC and Mr. Robert E. Coward, who is now with the Aeronautical Systems Division, Wright-Patterson AFB, Ohio.

FOREWORD

In March 1980, it was reported that a few Navy personnel were experiencing some unsteadiness and discomfort while flying the Air Combat Maneuvering Simulator (ACMS), designated Device 2E6. The discomforting symptoms described, especially when not associated with real motion, are usually referred to as "simulator sickness" to differentiate them from true motion sickness.

Recognizing the need for pursuing this matter further, this study was initiated by the Naval Training Equipment Center (NAVTRAEQUIPCEN) to determine the extent of the problem. CDR Charles Hutchins of the Naval Air Systems Command (COMNAVAIRSYSCOM)(AIR 340F) provided financial support for the study.

Results, obtained through questionnaires administered to 66 aircrew members from F-4 and F-14 squadrons, indicated that 27 percent (18 crew members) reported varying symptoms and degrees of simulator sickness. Although some pilots reported similar symptoms while flying aircraft, this study dealt primarily with simulator induced problems. However, some opinions concerning mental and physical fatigue experienced in the simulator compared to actual aircraft ACM training sorties, were also solicited.

In an attempt to compare the 2E6 experiences with those in a similar device, the NASA, Langley Research Center, Virginia was contacted in reference to the Differential Maneuvering Simulator (DMS) located at their facility. Detailed documentation of simulator sickness had not been kept on this simulator, but a NASA representative stated that out of 600 to 800 pilots who have operated this device, he could only recall two who experienced extreme simulator sickness. The effects on these pilots were so disorienting that they could not complete the training sessions. Unfortunately, less dramatic symptoms such as fatigue, headaches, excessive sweating, and other minor discomforts were not documented.

This brings up the question of the definition of "simulator sickness." The term has been used rather loosely and has included symptoms as mild as sweating or a slight disorientation, to more severe physical reactions including nausea and vomiting. Between these extremes are symptoms such as vertigo, dizziness, and visual, mental, or general physical fatigue. In some cases, the symptoms persist for several hours after leaving the simulator. In assessing a simulator for its adverse effects on the trainee population, it is important to be specific about the type of "sickness" it produces. In some cases, the symptoms may be minor and of a transient nature, and no worse than would be experienced under operational flight conditions.

There are several hypotheses that have been advanced in an effort to explain simulator sickness. It is probably safe to state that not all instances of this phenomenon can be explained

by any one hypothesis. One of the most favored explanations is that it is the result of conflict of sensory cues; for example, the conflict between the apparent motion seen on a visual display and lack of any corresponding real motion of the simulator. Another instance would be excessive time lag between the simulator control system and the corresponding movement in the visual display. Situation freeze also imposes sensory conflict on the pilot. In these cases, the visual and proprioceptive (bodily feel) senses are not in phase. This imbalance can create a perplexing state that may be manifested in some of the symptoms discussed above.

McDonnell Douglas Astronautics was also contacted to determine the manufacturer's experience with the dome simulator type systems representative of Device 2E6. Although varied populations (e.g. experienced and inexperienced pilots, civilian and military dignitaries, foreign visitors, etc.) operated the simulator, McDonnell employees could not recall any incidents of simulator sickness. All of their simulator missions, however, had been highly structured in procedures and of less than 30 minutes duration per session.

Another simulator system with different characteristics was also investigated. This was the Air Force's simulator for air-to-air combat (SAAC) which has produced sickness in 88 percent of the users. A direct comparison of the SAAC data to that of the 2E6 should be made with reservation, however, since training on this device is very intensive over a short period of time (approximately 12 hours of actual simulator use over a four-day period) and the visual systems are of different types (dome projection real image vs "pancake window" virtual image display on SAAC). This comparison is useful in some respects, however, since it demonstrates that despite the high incidence of discomforting sensations, it continues to be used for training. The consensus of Tactical Air Command (TAC) pilots who have participated in the training program is that the temporary discomfort brought on by these symptoms is a small price to pay for the kind of combat training provided by the device. Another useful bit of information gained from this simulator corroborates the adaptation phenomenon. Most occurrences of nausea experienced on the SAAC took place during the first one or two days of training. There was a marked reduction in nausea later on in the week.

There are two recommendations already in effect at the 2E6 simulator complex that are designed to reduce the incidence of sickness. One is limiting the time duration of individual sessions to 30 minutes. The second is flooding the simulator area with light before visual system freeze.

With no detailed training syllabus available for guidance, operation of the Device 2E6 is being conducted in a non structured manner. It has been noted that the length of individual

sessions vary and in some cases may be excessive. Uninterrupted time and specific tasks in the simulator, of course, are important considerations in evaluating the severity of the problem. Once a structured curriculum is adopted, the incident of simulator sickness can be studied further and perhaps reduced by curriculum refinement and/or other changes in use. Therefore the integration of a comprehensive training syllabus into the Device 2E6 program is essential to the assessment of simulator sickness in this simulator.

The fleet is currently establishing a Fleet Project Team to coordinate and direct efforts related to all ACM training objectives and requirements. One effort will be directed at integrating the 2F112, 2E6 and TACTS (Tactical Aircrew Combat Training System) syllabi.

The NAVTRAEQUIPCEN, with contractor support, will continue monitoring the occurrence of simulator sickness on devices 2E6 and 2F112 when a structured training program goes into effect and the new device modifications (e.g. ground-growth) are incorporated into the Device 2E6. At the conclusion of this study, another report will be issued with recommendations for alleviation of simulator sickness if any is found under the new circumstances.

Joseph A. Puig

JOSEPH A. PUIG
Scientific Officer

TABLE OF CONTENTS

SECTION I

INTRODUCTION

Introduction of wide-angle visual simulators into the operational and training communities of military aviation has been accompanied by reports of aircrews experiencing "simulator sickness." U.S. Navy aircrews have reported symptoms such as nausea, dizziness, headaches, and disoriented feelings while operating Device 2E6, Air Combat Maneuvering Simulator (ACMS). Reports of both delayed reactions and persistence of symptoms after leaving the trainer have raised concern over possible impact upon flight safety and negative training. This report details the methods and results of a short-term project undertaken to assess the rate of occurrence and the degree of severity of simulator sickness experienced by individuals who have flown the 2E6.

The 2E6 ACMS consists of two fixed-base, tandem crew cockpits, each surrounded by a 40-foot dome which approximates a 360-degree field of view. Visual scenes are created by projecting aircraft, missile and earth/sky scenes onto the domes. A more detailed description of the 2E6 is provided in Appendix A.

SECTION II

BACKGROUND

Occurrence of "motion sickness" symptoms in flight simulators has been reported in various simulators using wide angle visual systems (e.g., Miller and Goodson, 1960, and Coward, Kellogg and Castore, in preparation). The concern over the possible impact upon flight safety has prompted articles dealing with spatial disorientation (e.g., Porter, 1979, and Coward, Kellogg and Castore, 1979). Although the phenomenon has been known for years, identifying the reasons for "simulator sickness" is a difficult task. The causes are complex and, most probably, interrelated. While precise reasons for "simulator sickness" are not fully understood, research efforts are establishing a knowledge base which may someday provide the design specifications or procedures necessary to mitigate or eliminate the problem.

Prior research efforts have documented many of the types of "simulator sickness" conditions occurring in the 2E6. Four studies in particular provide insight into issues specific to the 2E6 and contribute to a better understanding of the problem as a whole. A brief description of each study follows, including a short synopsis of pertinent conclusions as they relate to the 2E6.

First Study
Puig, 1971

Puig (1971) provides a review of the problems associated with simulator sickness in a paper entitled The Sensory Interaction of Visual and Motion Cues. In this treatise, Puig states that an individual senses movements and accelerations by means of his visual system. He also receives and senses this information from within his own body through proprioceptive cues (i.e., through muscles, joints and inner ear). The visual and proprioceptive cues interact with each other. "Motion can be sensed visually and proprioceptively. Acceleration cannot be sensed visually, however, until increasing velocity is noted. Conversely, the proprioceptive sense, though insensitive to velocity, is quite sensitive to acceleration." Puig states that the body relates visual and "kinesthetic" (feel) and "vestibular" (balance) cues to interpret combinations of motion and/or accelerations. When an individual uses a fixed-base simulator, his eyes will sense motions and/or accelerations from the moving visual displays, while his

proprioceptive senses (particularly the vestibular) indicate that he is not moving or accelerating. The normal sensory interactions are disrupted and internal conflicts arise resulting in feelings of "uneasiness" or "simulator sickness." Thus, "it is not the visual illusion of motion per se, but the visual sensation of apparent acceleration and/or change in direction that triggers off the initial feeling of discomfort."

Puig further states that in addition to sensory conflicts, poor visual fidelity may also be a contributing factor in simulator sickness. "...in the presence of a well-structured visual display, therefore, the visual mode will be the primary overriding input. With a poor visual reference, however, the motion cues [vestibular response] will tend to take priority. In situations where the visual and motion inputs are sensed as being equally demanding, they will be reinforcing or contradictory depending upon whether the cues are in or out of phase."

Another potential complicating factor regarding simulator sickness mentioned by Puig involves a study (Olive, 1969) which correlated physical and medical data of 1,000 Naval aviators over a twenty-year period. The analysis indicated that susceptibility to vertigo and disorientation increase with age.

In reviewing previous research efforts, Puig reported ten hypotheses which have been advanced in an effort to explain simulator sickness:

1. Conflict between the apparent motion seen on the visual display and lack of any corresponding real motion of the simulator.
2. Optical distortion (both static and dynamic) in the visual display, particularly of vertical objects; the synthetic presentation of a visual scene which is a distorted representation of a real environment.
3. Poor resolution.
4. Rapid changes in brightness (flicker).
5. Wide field of view.
6. A highly structured field of view (too much detail).
7. A poorly structured field combined with peripheral flicker.
8. Excessive lag between simulator control and corresponding movement in the visual display.
9. High frequency vibrations which disrupt accommodation.
10. Projection screen-to-observer distance insufficient for infinity focus of the eyes, producing conflict between actual distance of the display and the apparent distance of the screen.

Puig concludes by emphasizing the necessity for considering the sensory interactions between the visual and vestibular apparatus when designing simulators with visual displays.

Second Study
Miller and Goodson, 1960

Miller and Goodson examined simulator sickness occurring among Navy helicopter pilots. During the early stages of visual flight simulation development, the Navy procured the 2-FH-2 helicopter simulator. The device was built by Bell Aircraft Company in conjunction with De-Florez Company of New York and installed at Ellyson Field, Pensacola, Florida in February, 1956. Two projectors provided 260 degrees azimuth by 75 degrees elevation display coverage. The upper projector displayed the sky scene while the lower projector depicted the near terrain, the far scenery and a portion of the sky. The cockpit was fixed-based. Significant occurrences of simulator sickness symptoms resulted from using the 2-FH-2.

In an attempt to identify some of the possible causes of the simulator sickness symptoms, Miller and Goodson mentioned that previous researchers suggested the symptoms were a result of internal conflicts resulting from the absence of real motion accompanied by the presence of visual cues designed to give the impression of movement. While admitting this might have been a contributing factor, they generally dismissed this hypothesis as a major consideration. They felt the slight accelerations and decelerations in a helicopter were too imperceptible to cause symptom onset. They suggested instead that the underlying problem involved conflicting visual cues resulting from distortions in the visual display rather than a conflict between visual and proprioceptive cues. Major findings included:

1. Sixty percent of the instructors reported sickness as compared to 12 percent for the students.
2. Sometimes the ill feelings did not occur until several hours after simulator usage.
3. One instructor had to get out of his car on his way home to regain his equilibrium.
4. Some instructors, after much simulator time, would experience significant discomfort from merely looking at the simulator.
5. Even those individuals who did not report sickness symptoms became very fatigued after simulator use; this condition often lasted throughout the day.
6. Lag in the simulator at times resulted in

overcontrol, sometimes leading to loss of control. The loss of control produced a violent maneuver; the more violent the maneuver, the greater the degree of simulator sickness.

7. Instructors sitting as passengers during these conditions were more prone to simulator sickness than if they were at the controls.

Miller and Goodson concluded their study by saying the simulator sickness problem became so serious that it was one of the chief reasons for discarding the device from the operational inventory.

Third Study
Reason and Diaz, 1971

In Reason and Diaz's study the effects of simulator sickness upon experienced automobile drivers as compared to passengers was examined. Reason and Diaz theorized that the major underlying cause of simulator sickness results from what they termed "sensory rearrangement." That is, an individual in his real-world experience learns to subconsciously associate visual scenes of motion with his proprioceptive senses of corresponding accelerations. An individual retains these associations in his "spatial memory store." The more experience a person has in these real-world experiences, the stronger the association that is stored in his memory. Thus, when real-world experienced individuals are placed in a simulator environment in which visual scenes of motion and acceleration are depicted without the accompanying acceleration forces, "unfulfilled expectations" occur. These experienced individuals expect to feel acceleration forces in conjunction with the visual scenes. When this does not occur, internal conflicts arise which can initiate onset of simulator sickness symptoms. Under this theory a novice would not be expected to be as apt to get sick as an experienced individual since the novice has not developed the "spatial memory stores."

Reason and Diaz felt the Miller and Goodson study partially bore out this theory by the findings that instructors experienced a five times greater incidence rate than their students. In a further investigation of the "sensory rearrangement" theory, Reason and Diaz examined individuals with automobile driving and passenger experience in an automobile driving simulator in which the individuals viewed a ten-minute driving scene as passive observers. The experiment used a 6 x 12 foot screen located six feet away from the subjects. Major findings included:

1. Twenty-eight out of the 31 individuals exhibited some form of simulator sickness.

2. Active participation in the control of the vehicle is not necessary in order to induce simulator sickness symptoms.
3. Women were significantly more susceptible to simulator sickness than men.
4. The more the driving and passenger experience of individuals the higher the degree of simulator sickness.
5. Evidence suggests that driver experience exerts a more powerful influence on simulator sickness than passenger experience.

Fourth Study
Coward, Kellogg and Castore, in preparation

In a study conducted on subjects training ACM in the Air Force Simulator for Air-to-Air Combat (SAAC), at Luke AFB, Arizona, Coward, Kellogg and Castore reported a simulator sickness incidence rate of 88 percent in the subjects interviewed. The SAAC is an ACM training system that utilizes cathode ray tube (CRT) displays to provide a near 360-degree field of view to the trainee. The six degree of freedom motion base was not used during the training of the subjects interviewed in the Coward, et al., study. The SAAC consists of two F-4 cockpit trainee stations, instructor operator stations and debrief stations. Capabilities include simulation of 1v1 ACM in an integrated mode or in an independent mode with each trainee flying against an instructor controlled or computer programmed target.

The SAAC students were reported to have high levels of operational experience; 50 percent had over 500 flight hours and 31 percent had in excess of 1000 flight hours. The SAAC subjects participated in one week of intensive training and experienced approximately 500 engagements in 12 hours of simulator time. The most prevalent symptoms reported were nausea - 79 percent; motor dyskinesia - 60 percent; and a sensation of being rotated in some orthogonal plane - 54 percent. Significantly, the study also reported persistence of symptoms up to ten hours after completion of simulator training and delayed reactions after training, such as visual "flashbacks" in as many as 33 percent of the subjects. Delayed reactions were also reported by the subjects involved in the Miller and Goodson study addressed above.

SECTION III

METHOD

The conduct of the study included the administration of a questionnaire presented during individual interviews. The questionnaire (a copy is included as Appendix B) solicited information concerning experience levels in ACM flight training, experience in visual simulators and the type and degree of severity of sickness symptoms. The interviews were conducted in squadron spaces away from the simulator complex. Each individual was carefully briefed concerning confidentiality of any information which he provided.

The sample of subjects was selected on the basis of availability and experience in the use of the 2E6 ACMS. The Commanding Officers of the four squadrons involved were briefed thoroughly on the confidentiality and content of the questionnaire and were included as subjects in the interviews. A total of 66 subjects were interviewed. The group included 65 individuals from four separate fighter squadrons and one test pilot from the Naval Air Test Center (NAVAIRTESTCEN), Patuxent River, Maryland. All subjects were exposed to the 2E6 through squadron training programs or as a result of personal interest in the device, with the exception of the NAVAIRTESTCEN test pilot. The experience level of the subjects ranged from 250 to 4000 flight hours; all were operational fleet aircrew members. The training they received consisted of four flight missions of one hour duration and was generally designed as a structured prelude to an Air Combat Maneuvering program. The simulator "instructor" operator position was normally assumed by a peer, aircrew member, or training device operator (TD).

SECTION IV

RESULTS

The study indicated that 27 percent of the aircrew members interviewed experienced some degree of simulator sickness symptoms. Table 1 provides a breakdown of the subjects according to aircrew designation, types of aircraft flown and extent and related numbers of symptoms experienced. Of the total subjects interviewed, 39 were Pilots and 27 were Radar Intercept Officers (RIOs). The flying experience of the subjects and the rate of occurrence is presented in Figure 1. The highest incidence rate of simulator sickness occurred among those aircrew members (22) with more than 1500 flight hours in which 47 percent of the subjects reported some degree of symptoms (Figure 2). Forty-four aircrew members had 1500 or fewer flight hours with 18 percent reporting sickness symptoms. (Note: As flight hours increase, N decreases and reliability decreases.) The rate and type of symptom occurrence is reported in Appendix C.

The severity of symptoms ranged from mild to severe. In several cases subjects terminated the training sessions because of the severity of sickness onset. None of the subjects reported emesis, but several reported loss of appetite until after a sleep period; in each of these cases, the symptoms subsided completely after a night's rest. The most common symptom reported was dizziness which occurred in 17 percent of the subjects interviewed (Figure 2); vertigo and disorientation were reported by 11 percent of the subjects; "leans" and nausea were noted by nine percent.

Although each subject was asked if he experienced "flashbacks" or "visual replays", no occurrences were reported among the 66 aircrew members interviewed. Subject number 7 (Appendix C) is an Air Force exchange pilot flying with the Navy who is a graduate of the USAF SAAC training program. During his SAAC training he experienced visual "flashbacks" but did not experience these symptoms when training in the 2E6. The subject reported, during the course of his SAAC training, "seeing the checkerboard pattern of the SAAC background display painted on the inside of my eyelids" when lying down to sleep. The symptoms terminated after the last day of flying in the SAAC and did not recur. (These reported simulator sickness symptoms are consistent with findings from Coward, Kellogg and Castore; discussed in Section II.) Subject number 7 stated the SAAC CRT display was much harder on the eyes than the 2E6 display. He experienced no simulator sickness symptoms during his six hours of 2E6 use.

TABLE 1. DATA SUMMARY

Sixty-five total individuals interviewed from four fighter squadrons plus one NAVAIRTESTCEN test pilot.

Number of Aircrew Members Interviewed and Reporting Sickness Symptoms

Aircrew Position	Number Interviewed	Number Reporting Sickness Symptoms	Percentage Reporting Sickness	Category
Pilots	21	9	42.9%	F-4
RIOs	16	3	18.8%	
Pilots	18	5	27.8%	F-14
RIOs	11	1	9.1%	
Pilots	39	14	35.9%	TOTAL
RIOs	27	4	14.8%	

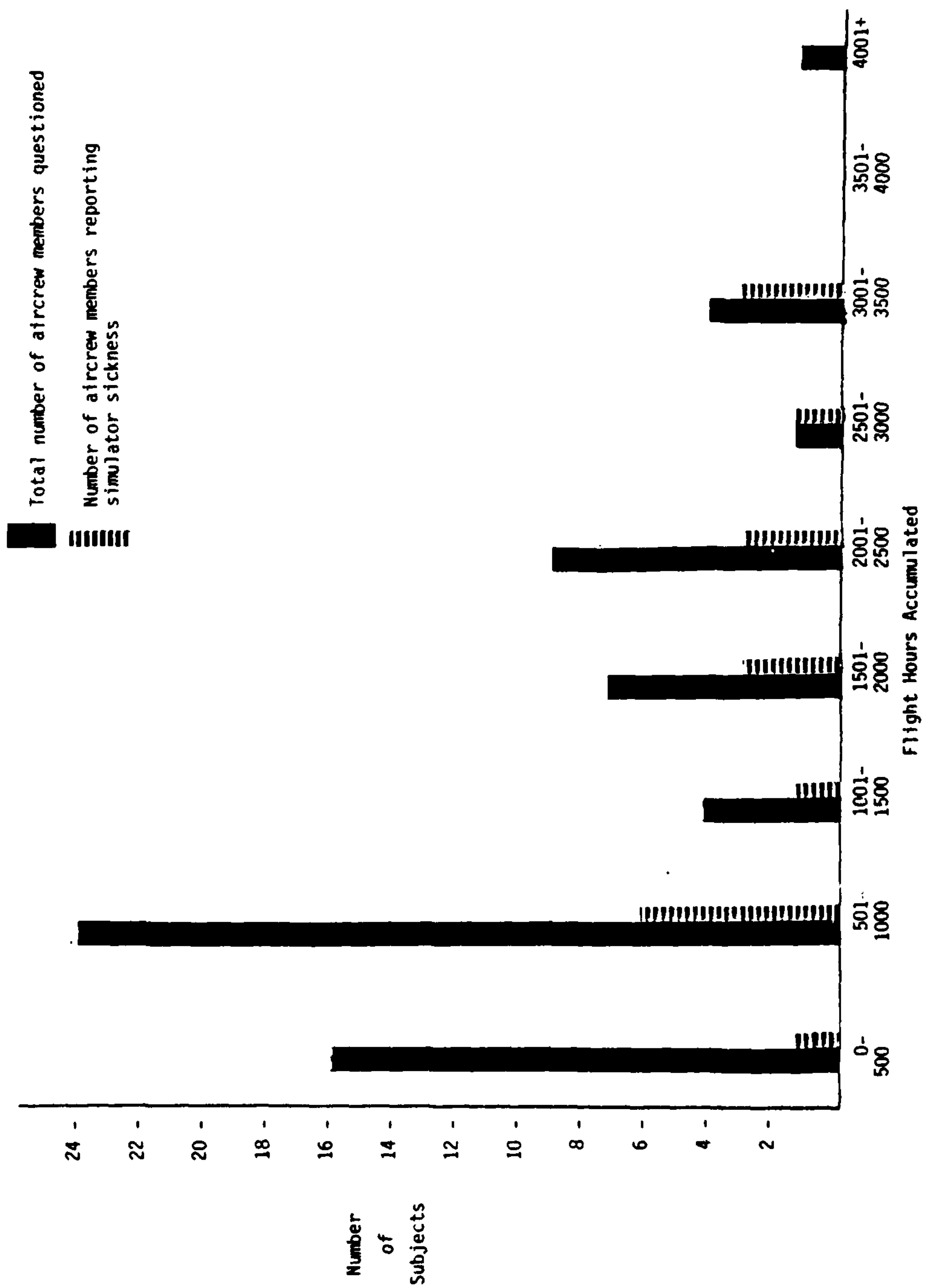

Figure 1. Simulator Sickness Symptom vs. Flight Hour Experience

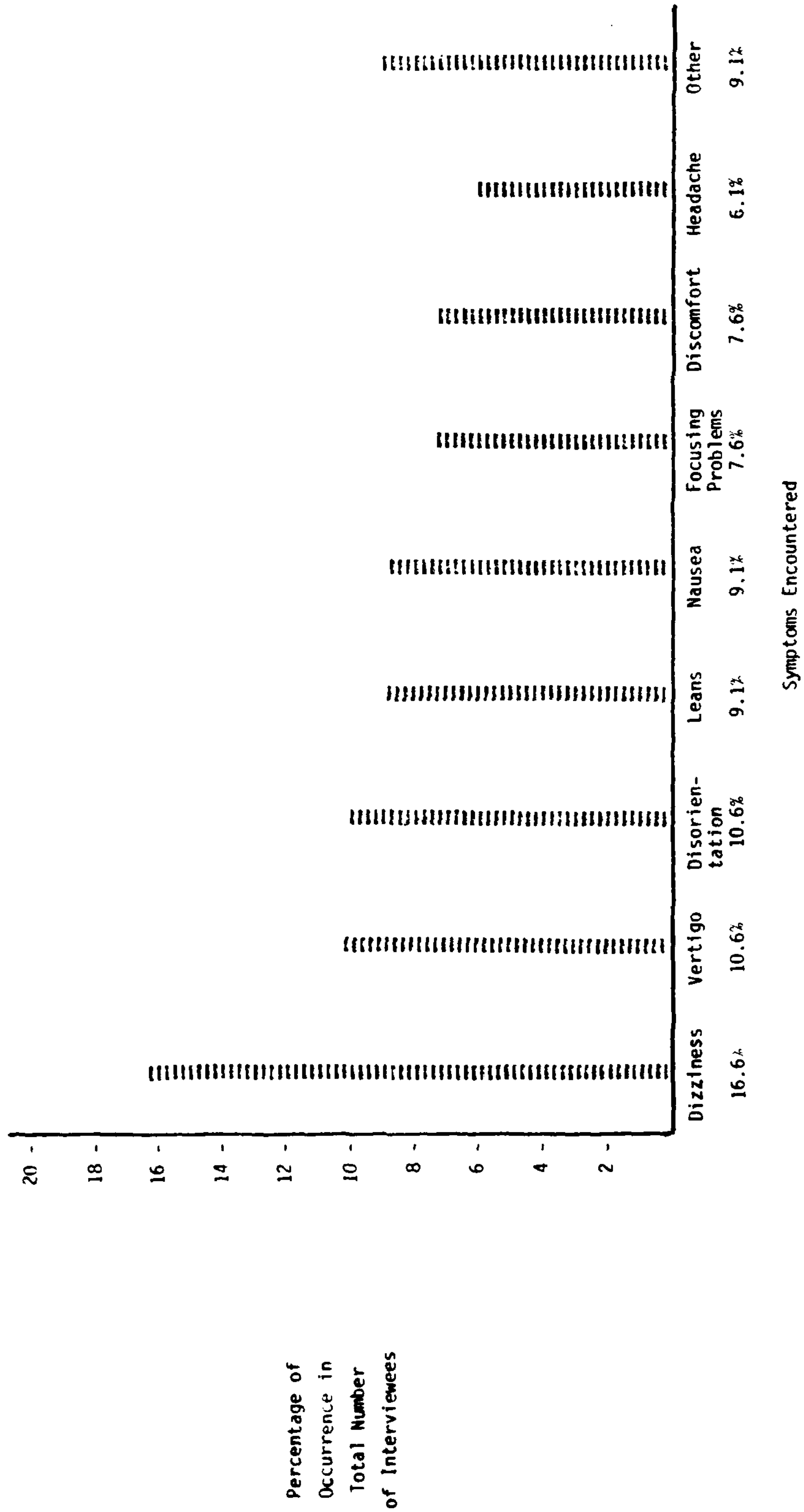

Figure 2. Symptom Occurrence

Mental fatigue was reported as being the same, greater or less than actual ACM flight training by equal numbers of the subjects. However, as reported in Table 2, 83 percent of the subjects interviewed reported physical fatigue as being equal to that experienced in the air during ACM training. All but three percent of the subjects interviewed reported perspiring less or much less than in actual flight, the exception being profuse sweating accompanied by nausea for some of those individuals experiencing simulator sickness.

There were some unique symptoms reported. These were "eyeball jitter," tired feeling, loss of depth perception, knees weak, and fullness of the stomach. One aviator reporting "eyeball jitter" had participated in tests to examine the cause of this phenomenon in centrifuge experiments. The occurrence of this unique symptom may demonstrate a preconditioned body response which was transferred from the centrifuge to the fixed-base simulator.

Only two subjects reported delayed reactions in which symptom onset occurred after leaving the trainer. However, 61 percent of those experiencing symptoms reported persistence of the symptoms from 15 minutes up to six hours.

Another subject of special interest, due to his intensive exposure to the 2E6, is reported individually (subject number 19). He is a test pilot with 3400 hours of flight time conducting tests on the simulated aircraft models utilized in the 2E6. His experience in the 2E6 consisted of four hours per day for five consecutive days. His symptoms were described as severe, with nausea bordering on emesis, and persisting until after a night's sleep. The symptoms were most severe after the second day's training and dissipated over the next three days. He attributed the lessening of symptom severity to breaking his mission into 30 to 45 minute periods with 30 minute breaks and becoming familiar with the visual system. At the end of the fifth day, the subject reported mild disorienting feelings that persisted until bed time. Specifically, the subject stated he would not fly on a day in which he participated in a 2E6 training period. This experience relates closely to findings by Coward et al., dealing with intensity and length of training.

Possible Simulator Sickness Causes

The "reset"[1] function was reported by 33 percent of the subjects experiencing symptoms as being the most probable cause of symptom onset. Performing loops and nose high

---

[1]"Reset" - the freezing of the simulator visual display and returning to a new set of initial conditions.

TABLE 2. INTERVIEWEE OPINIONS CONCERNING RESULTING 2E6 MENTAL AND PHYSICAL FATIGUE

<u>Mental Fatigue in Relationship to Actual Aircraft ACM Training Sorties</u>

Greater in 2E6	33.3%
Same in 2E6	33.3%
Less in 2E6	33.3%

<u>Physical Fatigue in Relationship to Actual Aircraft ACM Training Sorties</u>

Greater in 2E6	11.1%
Same in 2E6	83.4%
Less in 2E6	5.5%

attitudes without visual altitude references was reported by an additional 44 percent as being a contributing factor to the onset of symptoms. The twilight environment of the display was also reported to be disturbing by 20 percent of the subjects.

SECTION V

DISCUSSION

DIFFERENCES AMONG 2E6 USER GROUPS

Flight experience, aircrew position (function), and type of aircraft all revealed certain relationships to simulator sickness susceptibility.

Flight Experience

The hypothesis advanced by Miller and Goodson (1960), that experienced aviators are more susceptible to simulator sickness than their less experienced counterparts is supported by the results of the present study. Aviators with more than 1500 hours of flying experience sustained a symptom occurrence rate of 50 percent, while aviators with 1500 hours or less sustained a symptom occurrence rate of 28 percent. The significant disparity between the two groups may indicate a greater degree of conflict between visual and proprioceptive senses because of increased preconditioning gained through airborne experience. Physiological body changes resulting from physical aging may also be a contributing factor to this phenomenon, since those with more flight hours naturally tend to fall into older age groups (Puig, 1971).

Aircrew Position (Function)

More pilots (36 percent) reported simulator sickness symptoms than RIOs (15 percent). These findings support Reason and Diaz's (1971) observations from an automobile driving experiment which indicated those with driving experience might be more susceptible to simulator sickness than those with only passenger experience. Two hypotheses may account for these differences:

1. Internal body conflicts arise between the visual scenes and the "G" force and acceleration cues.

Pilots, particularly in tactical aviation, learn to rely heavily upon "flying by the seat of the pants" to perform their mission. This requirement stems from the necessity to focus nearly 100 percent of the visual attention span outside the cockpit in order to maneuver the aircraft to the "piece" of the sky which will accomplish the desired tactical objectives. During critical flight regions, slow airspeed or nose high maneuvers, changes in

"G" forces and accelerations serve to warn the pilot to momentarily focus his attention "inside" the cockpit and concentrate on controlling the aircraft to avoid out-of-control flight conditions. Thus, pilots are preconditioned to react to "G" forces and acceleration cues received through their "feel" senses. Since the "G" force and acceleration cues received by the "feel" senses do not correspond with the visual scene represented in the 2E6, conflicts may arise when pilots see visual scenes which initiate anticipatory signals from these senses. The conflict between feel and the visual scene may be greater in experienced individuals. Because of the increased conditioning of the "feel" senses in these individuals, the degree of uneasiness or "simulator sickness" may increase. This hypothesis is further supported by the fact that 44 percent of the aircrews reported loops and nose high attitudes as a contributing factor to the onset of simulator sickness symptoms. During vertical maneuvers, the airspeed tends to decay rapidly which requires sensitivity to subtle "G" force and acceleration cues to recognize when to focus one's attention inside the cockpit. It follows that absence of these cues in these situations might induce feelings of anxiety and contribute to conflicts between the visual scene presentations and the interaction of the internal "feel" senses of the aircrews, thus, inducing simulator sickness symptoms.

2. RIO and pilot training differences tend to make RIOs less susceptible and pilots more susceptible to simulator sickness.

Another contributing factor to the low number of simulator sickness reports for the RIOs may be their type of training background. During the undergraduate portions of the RIO training pipeline, they are tasked with conducting intercepts in the back of a T-39 aircraft with no access to windows for relating aircraft maneuvers to visual scenes. It has been reported within the community that this operating environment is very conducive to air sickness and individuals are "washed out" of training in this phase if they cannot overcome the negative effects of these symptoms. The remaining individuals have been conditioned to "deny" the conflict between the visual senses and the sensations created by "G" forces and accelerations in the performance of their missions. This is just the opposite of pilot training which requires developing increased sensitivity to the "G" forces and accelerations to perform their prescribed role.

The above discussions must remain hypotheses since there are confounding sources in the data. For example, in the "real world" and in the simulator, a RIO must perform a different type of visual timesharing task than does a pilot.

This also could account for the differences between RIO and pilot sickness rates.

Aircraft Type

The data indicates that F-4 aviators got sick more often than F-14 aviators. Forty-three percent of the F-4 pilots experienced symptoms while only 28 percent of the F-14 pilots reported sickness symptoms. This result may be related to differences in aircraft flight characteristics or to varied training approaches.

It should also be noted that many potentially confounding factors may have influenced these preliminary findings. For example, F-14 aircrews had not used the 2E6 in over 90 days at the time of the interviews while the F-4 aircrews had utilized the 2E6 within 30 days of the conduct of the interviews; therefore, memory decay could have resulted in fewer reported cases of F-14 aircrew sickness. Also, other factors such as age, which might affect results, were not analyzed. Further analysis is required before firm conclusions can be drawn.

DIFFERENCES BETWEEN THE 2E6 AND SAAC

This preliminary effort revealed that fewer individuals are reporting simulator sickness in the 2E6 than in the Air Force SAAC. Simulator sickness occurred in 27 percent of 2E6 subjects and their symptoms appeared less severe than the 88 percent sickness rate reported in the SAAC (Coward, Kellogg and Castore, in preparation). Differences in utilization of the simulators, fidelity, degree of realism/capability and visual display hardware make it impossible to precisely determine why these differences are occurring at the present time. However, a preliminary cross-comparison of these differences may provide some insight into the problem.

Manner of Use

The subjects experiencing simulator sickness in the SAAC were generally exposed to the simulator through a well-defined, intensive syllabus and experienced more hours of training in a more compressed period of time. The greatest number of 2E6 subjects, nearly 50 percent, had five or less total hours of simulator time, taken in one hour time blocks in a five to ten day period. In comparison, the SAAC subjects received 12 hours of simulator time in a five day period. Additionally, the SAAC subjects experienced

their training in a concentrated, structured environment, while the 2E6 subjects trained in a more conventional setting. These differences in the training programs might account for some of the disparity between the 2E6 and SAAC in the percentages of aircrews reporting simulator sickness.

Only one of the 2E6 aircrew members interviewed experienced the intensity of simulator usage which the SAAC aircrews experienced (Subject 19, Appendix C). Significantly, he was the only subject interviewed whose symptoms persisted until after a full night of rest. He also experienced the greatest variety of symptoms and the most severe episodes of nausea.

Fidelity

Miller and Goodson (1960) reported the low fidelity of the visual display in the 2-FH-2, specifically the distortion apparent in the visual scene, as a primary contributor to the onset of symptoms. The 2E6 display, however, while having a low degree of structure in the field of view, has very little distortion. It is felt that low structure in the field of view does not induce significant occurrences of symptoms. However, low light levels, flicker and a nondescript background may play a limited role in initiating simulator sickness onset.

Realism/Capability

The "ground growth" and "progression" features of the SAAC (not currently installed in the 2E6) enhance the realism by providing visual cues representing changing altitude and velocity. While these features are highly desirable for ACM training, they may provide the trainee with a greater degree of conflict between the missing proprioceptive cues and the enhanced visual motion cues. It is possible, that if these features were to be incorporated in the 2E6, some increase in the incidence rate of simulator sickness may occur.

Visual Display Hardware

Differences in visual display hardware appear to account for variations in symptoms, also. The 2E6 projects model images onto a domed screen 20 feet from the aircrews. Aircrews observe indirect image displays reflected from the dome screen. The SAAC on the other hand, surrounds the aircrews with large CRT displays located three to four feet away from the aircrews. SAAC aircrews view direct light CRT

displays collimated at infinity. Interestingly, one-third of the SAAC aircrew members from Coward's study (in preparation) reported instances of involuntary "flashbacks" or "after images" following SAAC training sessions. But, out of 66 2E6 users interviewed, no instances of flashbacks were reported.

Numerous crossing attacks referred to as "high-angle gunshots" were practiced on the SAAC. Considering Young's (1977) studies at the Massachusetts Institute of Technology on peripheral viewing, this is an important point to consider in evaluating the occurrence of simulator sickness in the SAAC.

The Advanced Simulator for Pilot Training (ASPT) located at Williams AFB uses the same type of visual display as the Luke AFB SAAC. During on-site discussions with ASPT personnel, experiences of trainees in the ASPT were reported as similar to those experienced in the SAAC. Although incidence rates for the ASPT were not available, a tape of one subject's experience in the ASPT was reviewed in which he described symptom occurrence, severity and persistence nearly identical to those of SAAC trainees.

Certain amounts of simulator sickness may occur in all simulators utilizing wide-angle visual systems. It is felt, however, that the training benefits which can be derived from these dynamic visual displays far outweigh the negative impact resulting from the simulator sickness phenomena. Experimental laboratory research efforts are continuing to try to determine the platform motion requirements for wide-field visual display simulators (e.g., Young, 1977). It may be feasible some day to correctly mate motion/force platforms with visual display presentations and mitigate incidents of simulator sickness. In the meantime, applied research efforts which can more thoroughly compare operational equipment and user differences might be capable of more accurately ascertaining the internal body functions which lead to the onset of simulator sickness. Once these internal body functions have been positively identified, simulator design engineers may be able to construct simulators which will reduce or eliminate this problem.

Since the Air Force study on SAAC was completed, there has been significantly less apprehension and simulator sickness among the students. This is probably the result of a new briefing procedure that was initiated to familiarize them with the problem. After they were briefed on what to expect in the simulator, the students seemed to feel more comfortable and better able to cope with the discomfort, especially after being told that others were affected also but that they adapted readily with time. In essence, they were told: "The symptoms are very transient and you will adapt to it (the simulation)." (Personal communication with Mr. Robert E. Coward.)

REFERENCES

Coward, R.E., Kellogg, R.S. and Castore, C.H. Which Way is Up...or SAACing the Dizzies. TAC Attack, December 1979, Vol. 19, 12, 12-14, Tactical Air Command, USAF.

Coward, R.E., Kellogg, R.S. and Castore, C.H. Psycho-Physiological Effects of Training in a Full-Vision Simulator: the Visual Impact of SAAC. Air Force Human Resources Laboratory, Williams AFB, AZ, (in preparation).

McDonnell Douglas Corporation. (Preliminary) Instructor Handbook: Air Combat Maneuvering Simulator Device 2E6. NAVTRADEV P-4448. 1 December 1979.

Miller, J.W. and Goodson, J.E. Motion Sickness in a Helicopter Simulator. Aerospace Magazine, March 1960, Vol. 31, 3, 204-212.

Parrish, R.V. Experiments in Sensing Transient Cues on a Flight Simulator. Langley Research Center, Hampton, VA, NASA Tech. Paper 1537, 1979.

Porter, G.R. Spatial Disorientation. TAC Attack, December 1979, Vol. 19, 12, 4-6, Tactical Air Command, USAF.

Puig, J.A. The Sensory Interaction of Visual and Motion Cues. 25th Anniversary Commemorative Technical Journal, NTDC, November 1971.

Reason, J.T. and Diaz, E. Simulator Sickness in Passive Observers. Flying Personnel Research Committee, London, 1971, FPRC/1310 DIST. NTIC (AD 753560).

Young, L.R. Visually Induced Motion in Flight Simulation. Department of Aeronautics and Astronautics, MIT, Cambridge, MA, 1977.

BIBLIOGRAPHY

Albery, W.B., Gum, D.R., and Kron, G.J. Motion and Force Cuing Techniques for Advanced Tactical Aircraft Simulation (AFHRL/SM). Wright-Patterson AFB, OH, AGARD Meeting, Brussels, Belgium, 24-27 April 1978.

Barrett, G.V. and Thornton, C.L. Relationships Between Perceptual Style and Simulator Sickness. Journal of Applied Psychology, 1968, 52, 4, 304-308.

Benfari, R.C. Perceptual Vertigo: A Dimensional Study. Perceptual and Motor Skills, 1964, 18, 633-639.

Caro, P.W. Factors Influencing Simulator Training Effectiveness in the U.S. Air Force. Human Resources Research Organization, Alexandria, VA, 1977.

Hall, R.J. Motion Versus Visual Cues in Piloted Flight Simulation. HMSO, London, 1978.

Hall, R.J. Proposal for a Feasibility Study of a Visual Proprioceptive Display to Reduce Motion Sickness, Mission Research Corporation, Santa Barbara, CA, February 1978.

Irish, P.A. III and Buckland, G.H. Effects of Platform Motion, Visual and G-Seat Factors Upon Experienced Pilot Performance in the Flight Simulator. Flying Training Division, Williams AFB, AZ, Technical Report AFHRL-TR-78-9, June 1978.

Olive, J.R. Biological Communication. Abstract of Research by the American Institute of Biological Sciences for the Office of Naval Research, in DDC Report No. 8908, October 1969.

APPENDIX A

DESCRIPTION OF 2E6

The 2E6 Air Combat Maneuvering Simulator (ACMS) was installed at the Naval Air Station, Oceana, Virginia and became operational in November 1979. The device is designed to provide close-in Air Combat Maneuvering training. The device has two trainee stations (pilot and NFO in tandem cockpit configuration) located inside each of two 40-foot domes which provide a 360-degree field of view (see Figure A-1). Inside the domes are sky-earth projectors that project a blue sky and green-brown earth displays separated by a white haze band. The cockpits in the domes are mock-ups of the F-4J and F-14A and are interchangeable. Each cockpit is fixed-based with spatial orientation provided by computerized control of the sky-earth projector. There is no provision to simulate visual altitude cues or relative direction and velocity progression over the terrain.

Each dome is also provided with a missile projector, capable of displaying one missile in flight at a time, and target projectors capable of displaying two aircraft simultaneously. Four cathode ray tube projectors in each dome project a maximum of two targets and accurately simulate target altitude and range, from 300 feet to 25,000 feet.

An Instructor Operator Station (IOS) associated with each dome (or trainee station) provides control for that station in the independent mode or for both stations in the integrated mode. In the independent mode, all activity occurs in a single dome; the integrated mode requires an interaction of activity between domes. In either mode, a pilot can fly against a computerized bogie, if desired.

In either the independent or the integrated mode, the Instructor Pilot (IP) can choose computer control of a programmed target (adversary) or "choose to fly" the adversary himself from a modified throttle and stick at a control station located at the IOS (see Figure A-2). Each IOS and trainee station is operated by an independent computer system. Figure A-3 provides a functional diagram of the complete 2E6 ACMS.

A normal training mission consists of seven to ten engagements in a 30 to 45 minute period with each engagement lasting two to four minutes. At the beginning of each mission, the IP selects aircraft and adversary type, initial conditions (airspeed, altitude, heading), weapons, fuel loads and other mission specific criteria. The mission can be frozen in time and restarted from that point, reset to the initial conditions, or reset and new initial conditions

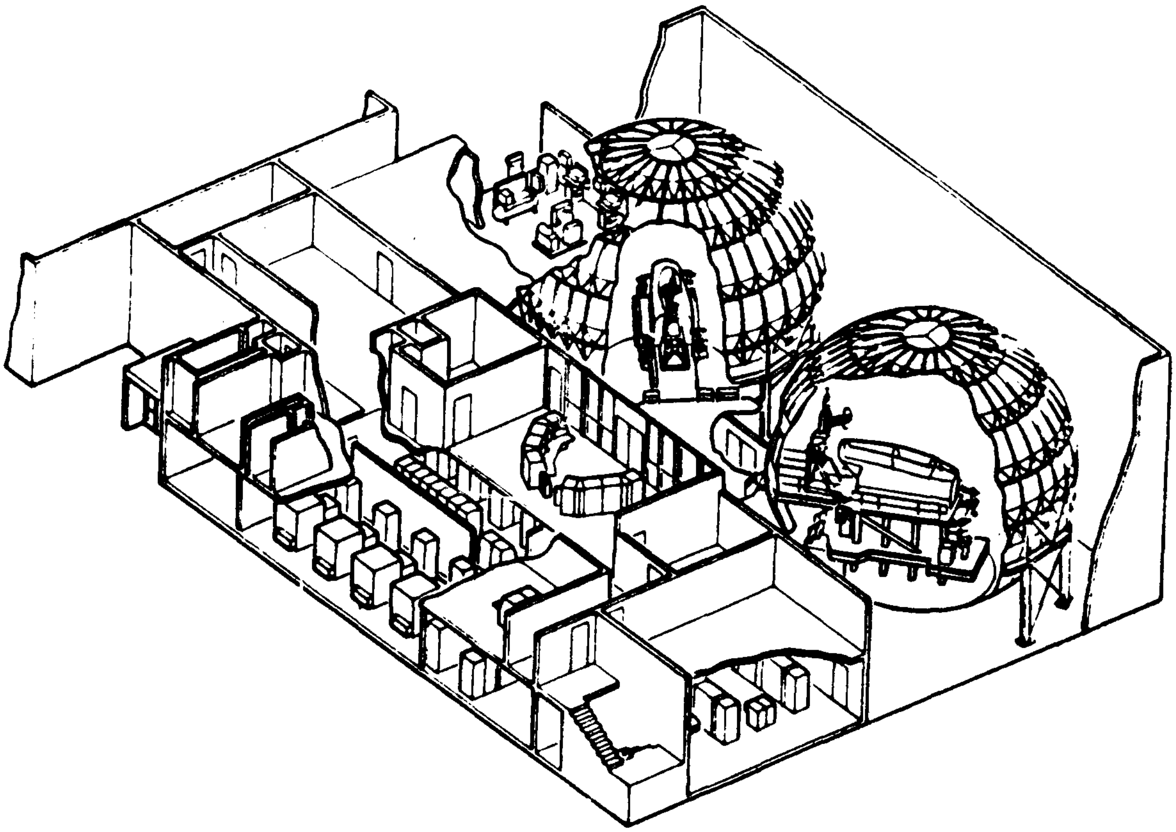

Figure A-1. Air Combat Maneuvering Simulator, Device 2E6

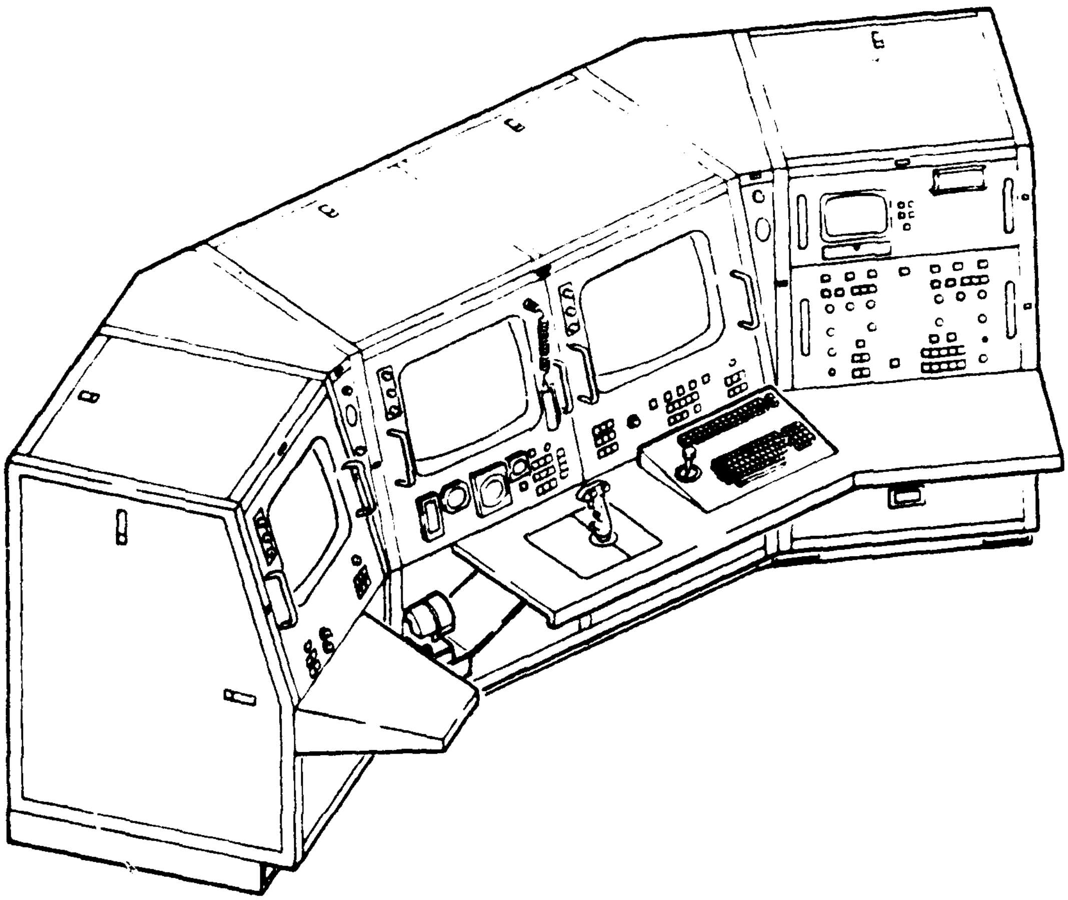

Figure A-2. Instructor Operator Station

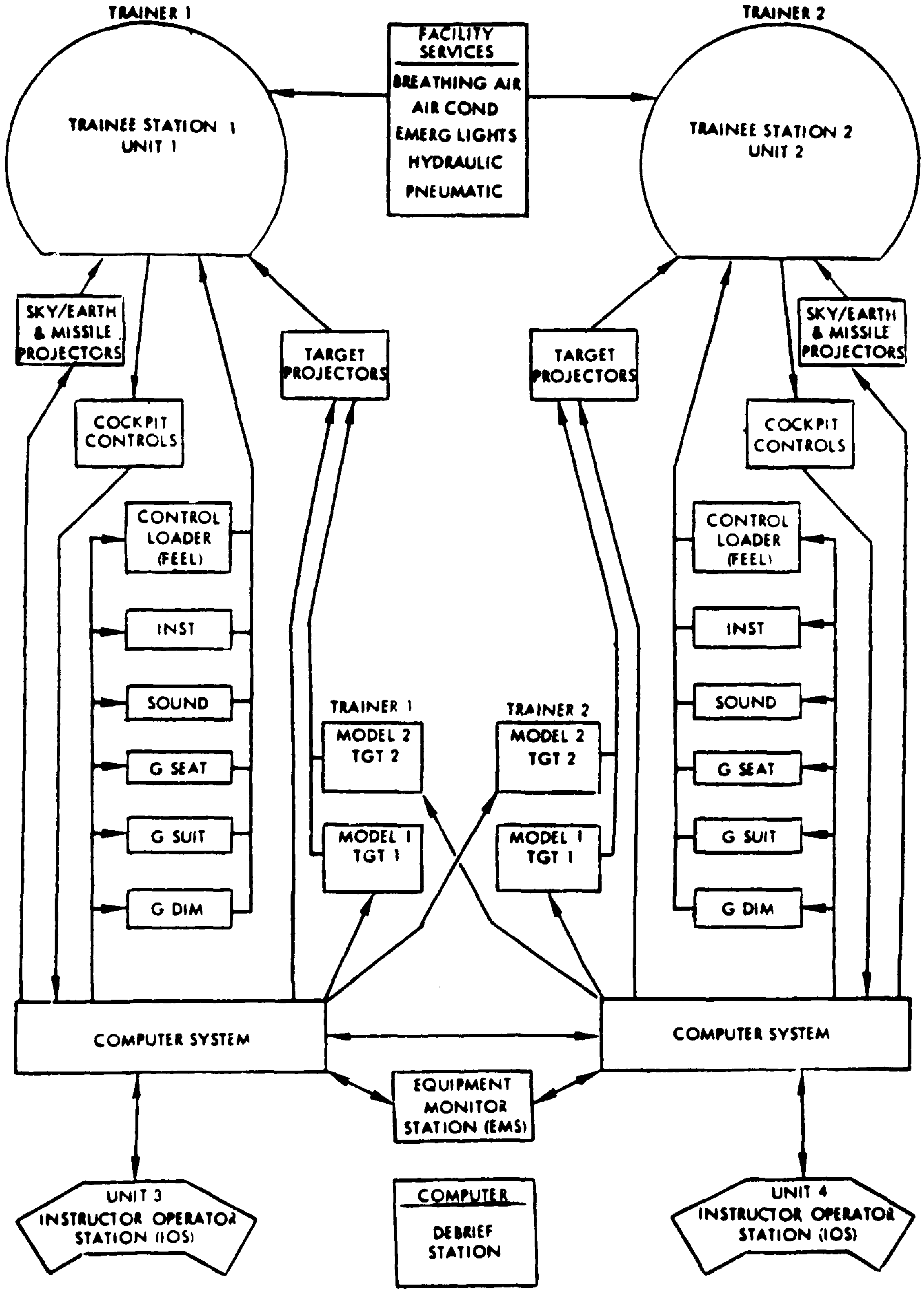

Figure A-3. ACMS Functional Diagram

selected. During the reset function all mission conditions are reset, including spatial orientation; the sky/earth display "snaps" back rapidly to the zero degrees pitch, roll and yaw.

Debrief of the mission is available at an independent console and display system, allowing extensive review and hard copy extraction of selected parameters. Up to 15 minutes of replay also is available within the dome. During replay, all training displays and conditions are replayed with the exception of aircraft control movement.

APPENDIX B

SIMULATOR EFFECTS QUESTIONNAIRE

Introduction

This questionnaire is designed to provide information pertinent to a study of the design and use of visual full-mission simulators such as the 2E-6 ACMS. The focus of the questionnaire is on reported cases of physiological symptoms similar to motion sickness or other forms of discomfort associated with simulator use in both the Navy 2E-6 and the Air Force Simulator for Air-to-Air Combat (SAAC).

The study is funded by Naval Air Systems Command through the Naval Training Equipment Center. Permission to circulate the questionnaire has been obtained from Commander Fighter Wing ONE. All information provided is confidential to this study.

The questionnaire items are directed at four categories:

General background information.

Discussion of any discomfort or symptoms associated during use of the 2E-6.

Discussion of any discomfort or symptoms which may occur after 2E-6 use.

General questions related to the application of the 2E-6 in ACM training.

The questionnaire will take approximately 30 minutes. We are very interested in your opinions. Very little information exists relative to the physiological effects of high technology simulator usage. Please be as specific as you can and feel free to add any comments you might have about the questionnaire or the general topic.

GENERAL BACKGROUND INFORMATION

1. How many total flying hours have you accumulated? ____________
   What aircraft types are you now current in? ____________
   How many hours do you have in each? ____________
   Are you an Aviator or Naval Flight Officer? ____________

2. How much experience have you gained in the 2E-6? ____________
   What was the average length of each period? ____________

3. Was your first exposure to the 2E-6 a result of a structured training program or personal interest? ____________
   What was the type of program and the amount of 2E-6 use? ____________

   ____

   ____

4. Have you had experience in visual simulators other than the 2E-6? ____
   Which simulators? ____________
   How much time in each? ____________
   For what purpose? ____________

   ____

   ____

   Did you experience any discomfort or symptoms of motion sickness in any of these trainers? ____________
   Please describe the symptoms you experienced in each trainer? ______

   ____

   ____

   ____

   ____

   ____

   ____

   Did you experience any other physiological effects such as profuse sweating while in these trainers? ____________

   ____

   ____

EFFECTS WHICH OCCURRED DURING 2E-6 USE

Using a flight simulator such as the 2E-6 presents aircrews with very distinctive visual cues. The lack of motion and the high fidelity of the synthetic visual display provided by the 2E-6 have been noted as being a possible source of discomfort reported by aircrews, or what the Air Force has termed "Simulator Sickness". The impact of the synthetic visual cueing is of great interest. The following questions seek to examine your opinions of visual simulator use of the 2E-6.

5. Did you experience an adequate introduction to the 2E-6 as a part of your first mission? ______________________

   How long were you in the dome on your first mission? __________

   Did you break your first training session into 1 or more training periods in the dome? ______________________

6. Did you experience symptoms of motion sickness or discomfort that you attributed to training in the dome on your first mission? __________

   ____

   How long were you in the dome when your symptoms occurred? __________

   What symptoms did you experience? ______________________

   Nausea? ______________________

   Dizziness? ______________________

   Leans? ______________________

   Feeling of being disoriented? ______________________

   Vertigo? ______________________

   Headache? ______________________

   Visual problems such as focusing? ______________________

7. Have you experienced discomfort or symptoms of motion sickness during successive missions? ______________________

   What were the symptoms? ______________________

   ____

   Specifically, did you experience any nausea while in the 2E-6? ______

   Do you now experience these symptoms when in the dome? __________

   If not, after how many mission/hours did the symptoms subside? ______

   In what order did the symptoms subside? ______________________

8. If you experience symptoms of discomfort or motion sickness in the trainer, can you identify a specific maneuver or simulator function that usually initiates symptom onset? ______________________________

   Did the aircrew member you were training with get sick on the same mission that you did? ______________________________

   Was the 2E6 fully operational or were there any known discrepancies on the flights in which you experienced your discomfort or symptoms?

   ____

   On missions which you experienced symptoms or discomfort, were you flying against the computer or another aircrew? ____________

9. While training in the 2E6, are there any particular distractions which interfere with your concentration on the tasks required to perform ACM?

   ____

   ____

10. When in the 2E6, how much do you perspire as compared to an actual ACM training flight?

    Much more   More   Same   Less   Much less

EFFECTS THAT OCCUR AFTER USING THE 2E-6

The following questions are pertinent to effects that occur after missions in the 2E-6.

11. Generally, how do you feel after completing a 2E-6 mission as compared to an ACM training flight?

	More Fatigued	Same	Less Fatigued
Physically			
Mentally			

12. After using the 2E-6, have you ever experienced any discomfort, visual after effects or other symptoms? ____________
What were your symptoms? ____________
____

What aspects of your simulator experience do you think caused the symptoms? ____________
____

13. After using the 2E-6, have you experienced any difficulty in reading of other CRT displays or any other type of displays? ____________
Reading books? ____________
Watching T.V.? ____________
Focusing difficulty? ____________
Headaches? ____________
Dizziness? ____________
Leans? ____________

14. If you experienced visual after effects (i.e., replay of visual sequences, flashbacks) that you associated with 2E-6 training, how long after the training session did they occur? ____________
What activity were you engaged in at occurrence? ____________
Please describe in detail the characteristics of the visual after effects.
____
____

Have you ever experienced flashbacks of any sort associated with any other activities r training? ______________________

Have the effects noted above subsided? ______________________

How long after your last training session did they subside? __________

GENERAL QUESTIONS RELATED TO 2E-6 TRAINING

The items below are of a general nature, but are important for an understanding of how simulator characteristics affect aircrews. The answers could impact the future design and implementation of simulators such as the 2E-6.

15. Can you identify any deviation from your normal ACM cockpit scan when training in the 2E-6? ____

    ____

16. When attempting to achieve a high G turn do you have the sensation of really pulling G? ____________ If so, what articles of flight gear were you wearing at the time? ____
    If not, have you flown in the 2E-6 with your normal flight gear on? ___

17. While training in the 2E-6, do you perceive differences in your ability to focus when transferring from outside the cockpit to inside as compared to inflight ACM training? ____
    Can you cite examples? ____

    ____

18. Prior to your experience in a visual mission simulator, what was your opinion of training ACM in a simulator? ____

    ____

    What is your opinion now? ____

    ____

    Do you see any difficulty in flying after a simulator mission? _______
    If so, why? ____

    ____

    ____

Provision of your name, organization and phone number on the questionnaire is voluntary and would only be used if information you provide on the questionnaire indicates further research is desired.

Name ______________ Organization ______________
Phone ______________

APPEN

SIMULATOR SICKNESS SYMP

S	Designator	A/C Type	2E6 Experience	Flight Hours	Prior Visual Experience	Nausea	Dizziness	Headache	Leans
1	Aviator	F-4J	4 hrs.	3200	No	Yes	Yes		Yes
2	Aviator	F-4J	6 hrs.	780	2B-35 4 hrs.		Yes		Yes
3	NFO	F-4J	3 hrs.	1000	No		Slight		Yes
4	NFO	F-4J	8-10 hrs.	2200	No				
5	Aviator	F-4J	4 hrs.	2000	No				
6	NFO	F-4J	3 hrs.	1800	No				
7	Aviator (1)	F-4J	6 hrs.	2500	SAAC 14 hrs.				
8	Aviator	F-4J	4 hrs.	2200	No				
9	Aviator	F-4J	4 hrs.	650	2B-35 8-10 hrs.			Slight	
10	Aviator	F-4J	18 hrs.	800	2B-35 5 hrs.* A-7 NCLT 5 hrs.		Yes		Yes
11	Aviator	F-4J	15 hrs.	1600	2B-35 4 hrs. A-7 NCLT 3 hrs.	Yes	Yes	Severe	
12	Aviator	F-4J	25-30 hrs.	1000	2B-35* 10 hrs.	Slight	Yes	Severe	Yes
13	NFO	F-14	4 hrs.	520	No		Momentary		
14	Aviator	F-14	8 hrs.	480	2F-95, 2B-35 10-15 hrs. each		Yes		
15	Aviator	F-14	4 hrs.	2800	No	Slight			
16	Aviator	F-14	4 hrs.	1300	No		Slight		
17	Aviator	F-14	2 hrs.	2400	NASA DMS* 10-15 hrs.	Yes	Yes		
18	Aviator	F-14	20 hrs.	3500	F-18 MAX 3* 2 hrs.				
19	Aviator	F-4S/J	20 hrs.	3400	No	Yes	Yes	Yes	Yes

(1) Visual Replays experienced in SAAC training did not occur in the 2E6 (information on the chart is relevant to SAAC experience). Subject 7 did not experience any sickness on Device 2E6.

*Ind
oth

APPENDIX C

NESS SYMPTOM OCCURRENCE

eadache	Leans	Vertigo	Visual Focusing Problems	Discomfort	Disorienting Feelings	Other	Onset	Persistence
	Yes	Yes		Yes			Simulator malfunction	6 hrs. after malfunction
	Yes		Yes				Operate initiate	Each mission, 15 mins. after completion
	Yes	Yes	Slight	Yes			First reset	2-3 hrs. after every mission
		Mild					Nose high maneuvers	3-4 mins. while in trainer
					Slight		Operate initiate	None after leaving trainer
		Yes			Yes		Upon entering trainee station	10 mins. while still in trainer
						Visual replay	Lying down to sleep (1)	Ceased 1 day after end of training (1)
		Slight			Slight		Nose high maneuvers	None
Slight		Slight	depth perception loss		Yes		After 1 hr. of operation	2 missions of 1-2 hrs. duration
	Yes	Yes			Yes		Operate initiate	10-15 mins. into each mission
Severe			Slight		Yes	Tired Feeling	45 mins. in trainer	3-4 hrs. after each mission
Severe	Yes						30 mins. in trainer	4 hrs. after every mission
			Yes			Weak knees, eyes hurt	Reset function	Unknown
							Reset function	30-45 mins. after leaving simulator
				Yes		Fullness in stomach	Immediately after leaving trainer	1-2 hrs. after each mission
						Light headed feeling	5 mins. after leaving trainer	10-20 mins. after each mission
							Operate initiate	3-4 hrs. after each mission
				Yes		Eyeball jitter	Reset function	1 min. while in the trainer
Yes	Yes		Yes	Yes	Yes		After 3 hrs. in trainer	Until after a sleep period

formation
ce any

*Indicates the same symptoms as described in other visual training experiences.

GLOSSARY

Emesis	Vomiting.
Flashbacks	Retinal after-images which occur following exposure to simulator visual scenes.
Ground growth	The expansion or contraction of the background visual scenes to simulate descents or ascents in altitude.
Ground progression	The movement of the background visual scenes in relation to the observer to simulate movement over the ground.
Independent mode	Permits the Instructor Operator Station (IOS) to control only one cockpit trainer.
Integrated mode	Permits the selected Instructor Operator Station (IOS) to control both cockpit trainers interactively.
Kinesthetic	Literally "feeling of motion"; refers to the sensitivity of movements of parts of the body (e.g., arms, legs, tongue and eyeballs) in relation to the whole due to the excitation of receptor cells located in the muscles, tendons and joints of the body.
Leans	A false sensation of bank or tilt.
Motor dyskinesia	Impairment of an individual's power of voluntary locomotion.
Ocular	Of or pertaining to the eye.
Proprioceptive	The sense of position, movement, pressure and equilibrium. It is divided into two major subclasses: Kinesthetic and Vestibular.
Reset function	The freezing of the simulator visual display and returning to a new set of initial conditions.
Vertigo	False sensation of bodily position and/or movement.
Vestibular	Involves the perception of spatial movements and spatial orientation of the body as a whole, resulting from excitation of receptor cells located in the nonauditory labyrinth of the ear.

DISTRIBUTION LIST

Commanding Officer
Naval Training Equipment Center
Orlando, FL 32813 (100)

Defense Technical Information Center
Cameron Station
Alexandria, VA 22310 (12)

(All other addressees receive one copy)

OUSDR&E (R&AT) (E&LS)
CDR Paul R. Chatelier
Washington, DC 20301

Chief of Naval Operations
OP-987H
Attn: Dr. R. G. Smith
Washington, DC 20350

Chief of Naval Material
MAT 031M
Washington, DC 20360

Chief of Naval Material
MAT 08D2
CP5, Room 678
Attn: Arnold I. Rubinstein
Washington, DC 20360

Commander
Naval Air Systems Command
AIR 340F
Washington, DC 20361

Commander
Naval Air Systems Command
AIR 413
Washington, DC 20360

Deputy Chief of Naval Operations (MPT)
Attn: Op-115
Arlington Annex, Room G836
Washington, DC 20370

Commander
Naval Air Development Center
Attn: Code 6022
Warminster, PA 18974

Dr. Sam Schiflett
Naval Air Test Center
SY 721
Patuxent River, MD 20670

Aerospace Psychology Department
Naval Aero Medical Research Lab (L53) 39
Naval Air Station
Pensacola, FL 32508

Chief of Naval Education and Training
Code N-2
Attn: CAPT Bauchspies
Pensacola, FL 32508

Chief of Naval Education and Training Support
Code 01A
Pensacola, FL 32509

Chief of Naval Technical Training
Code 0161
NAS Memphis (75)
Millington, TN 38054

Chief of Naval Air Training
Attn: Code 3146
NAS
Corpus Christi, TX 78419

Commander
Naval Air Force
US Pacific Fleet (Code 316)
NAS North Island
San Diego, CA 92135

Navy Personnel Research and Development Center
Attn: M. McDowell
Library, Code P201L
San Diego, CA 92152

Dr. Henry M. Halff
Office of Naval Research
Code 458
Arlington, VA 22217

TAWC/TN
Eglin AFB, FL 32542

USAHEL/USAAVNC
Attn: DRXHE-FR (Dr. Hofmann)
P. O. Box 476
Ft. Rucker, AL 36362

Chief
ARI Field Unit
P. O. Box 476
Ft. Rucker, AL 36362

Mr. Harold A. Kottmann
ASD/YWE
Wright-Patterson AFB, OH 45433

Chief, Methodology and Standards Staff
Federal Aviation Administration
Academy
Aeronautical Center, AAC-914
P. O. Box 25082
Oklahoma City, OK 73125

Headquarters
Air Training Command, XPTI
Attn: Mr. Goldman
Randolph AFB, TX 78148

AFHRL/MP
Brooks AFB, TX 78235

US Air Force Human Resources Lab
AFHRL-MPM
Manpower Personnel Division
Manpower & Force Management Systems Br.
Brooks AFB, TX 78235

US Air Force Human Resources Lab
AFHRL-FT
Flying Training Division
Attn: Dr. Edwards
Williams AFB, AZ 85224

Chief of Naval Education and Training
Liaison Office
Human Resource Laboratory
Flying Training Division
Williams AFB, AZ 85224

Mr. R. E. Coward
ASD/YWB
Wright-Patterson AFB
Dayton, OH 45433

Scientific Technical Information Office
NASA
Washington, DC 20546

Dr. Jesse Orlansky
Institute for Defense Analyses
Science and Technology Division
400 Army-Navy Drive
Arlington, VA 22202

US Air Force Human Resources Lab
TSZ
Brooks AFB, TX 78235

AFHRL/PE
Brooks AFB, TX 78235

US Air Force Human Resources Lab
AFHRL-TT (Dr. Rockway)
Technical Training Division
Lowry AFB, CO 80230

AFHRL/MP
Brooks AFB, TX 78235

Naval Biodynamics Laboratory
Box 29407
Attn: CDR Robert S. Kennedy
New Orleans, LA 70189

Commander, Naval Air Force
U.S. Atlantic Fleet (R. Goodwin)
Norfolk, VA 23511

Commander, Naval Air Force
U.S. Pacific Fleet (J. Bolwerk)
NAS North Island
San Diego, CA 92135

Commander, Tactical Wings, Atlantic
(CAPT Lusk)
NAS Oceana
Virginia Beach, VA 23460